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(54) Abstract Title
Dissolvable release mechanism for travel joints

(57) A dissolvable release mechanism to allow a travel joint to be run down-hole in a locked position to accommodate full compressive and tension loading integrity. The joint is released through exposure to caustic well fluids to accommodate well formation fluctuations in compressive and tensive forces. As oil or gas is removed from a lateral bore compresssive and/or tensive forces are produced by formation settling. A branch bore 14 is provided with one or more travel joints 100 designed to prevent the production tubing buckling. The release mechanism for the travel joint 100 comprises a dissolvable snap ring 800 positioned between an inner travel joint tube (200, figure 2C) and an outer travel joint tube 500. Once the production tubing is in position caustic drilling fluids are pumped through and the snap ring 800 dissolves over a period of time. The removal of the snap ring 800 allows relative movement between the inner and outer tubes of the joint in response to any external forces.

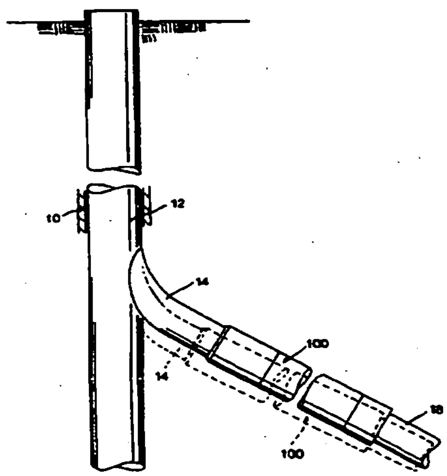

Fig. 1

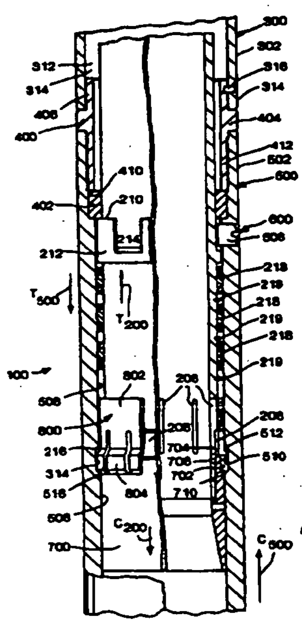

Fig. 2B

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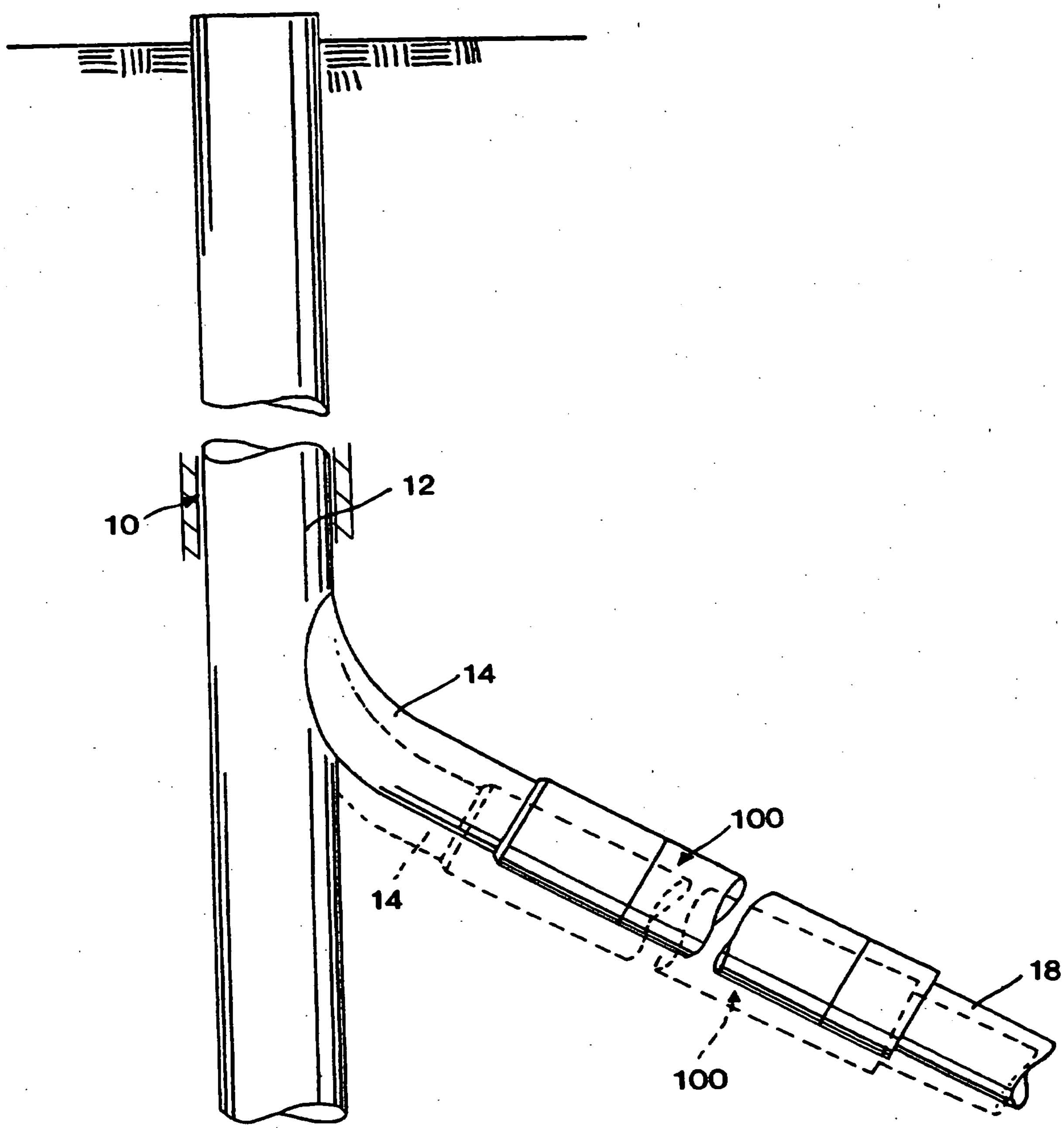

Fig. 1

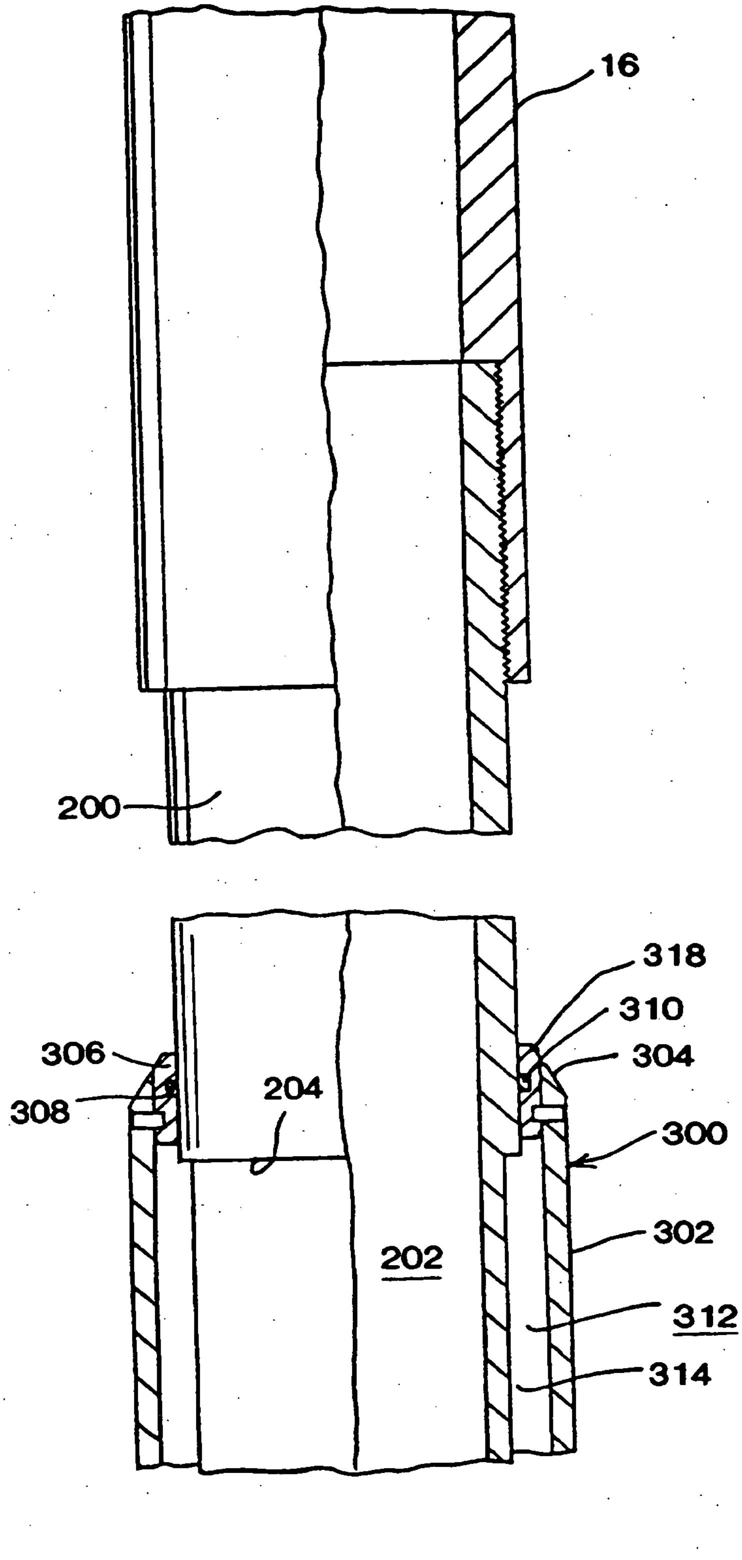

Fig. 2A

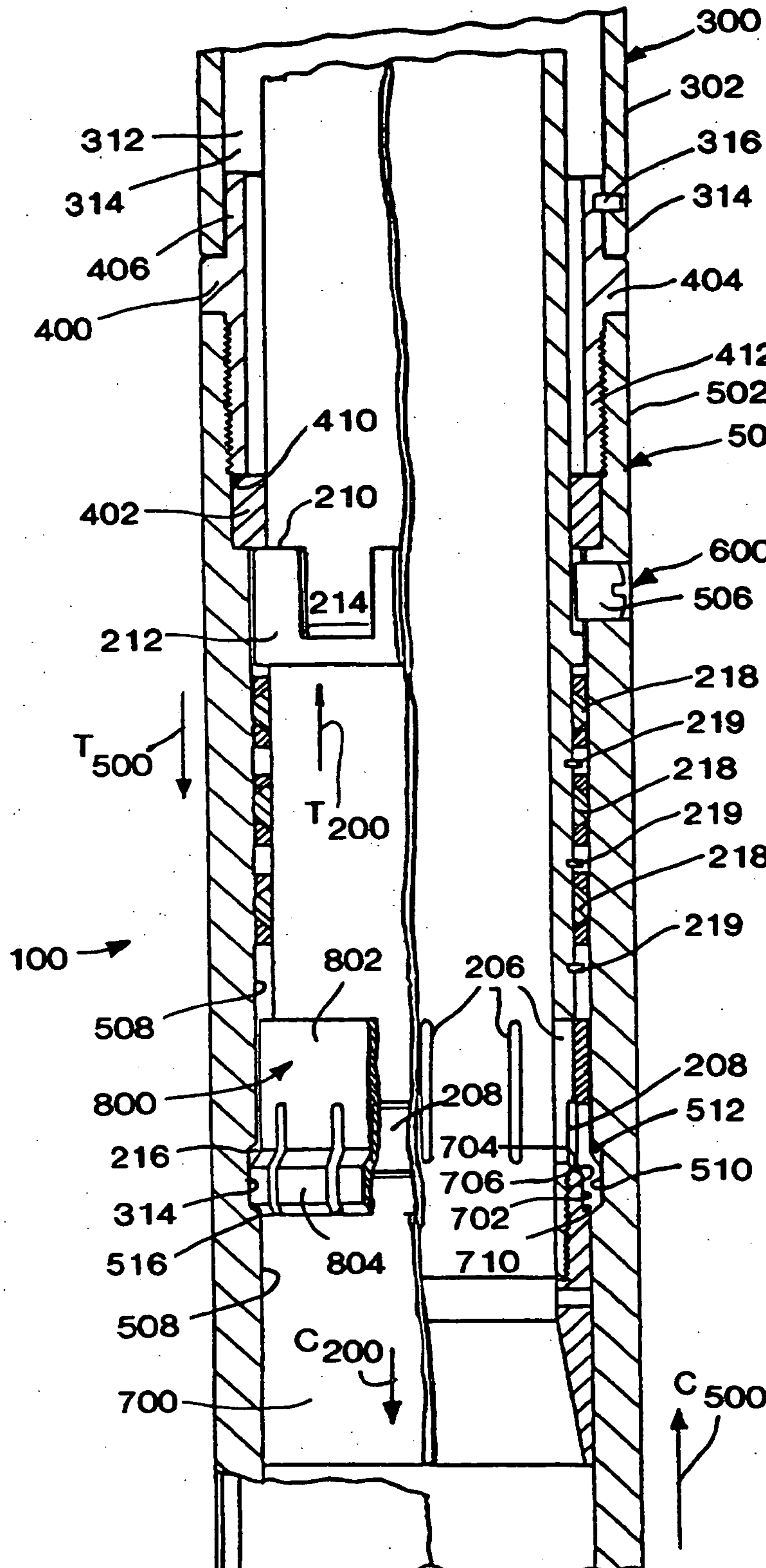
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Fig. 2B

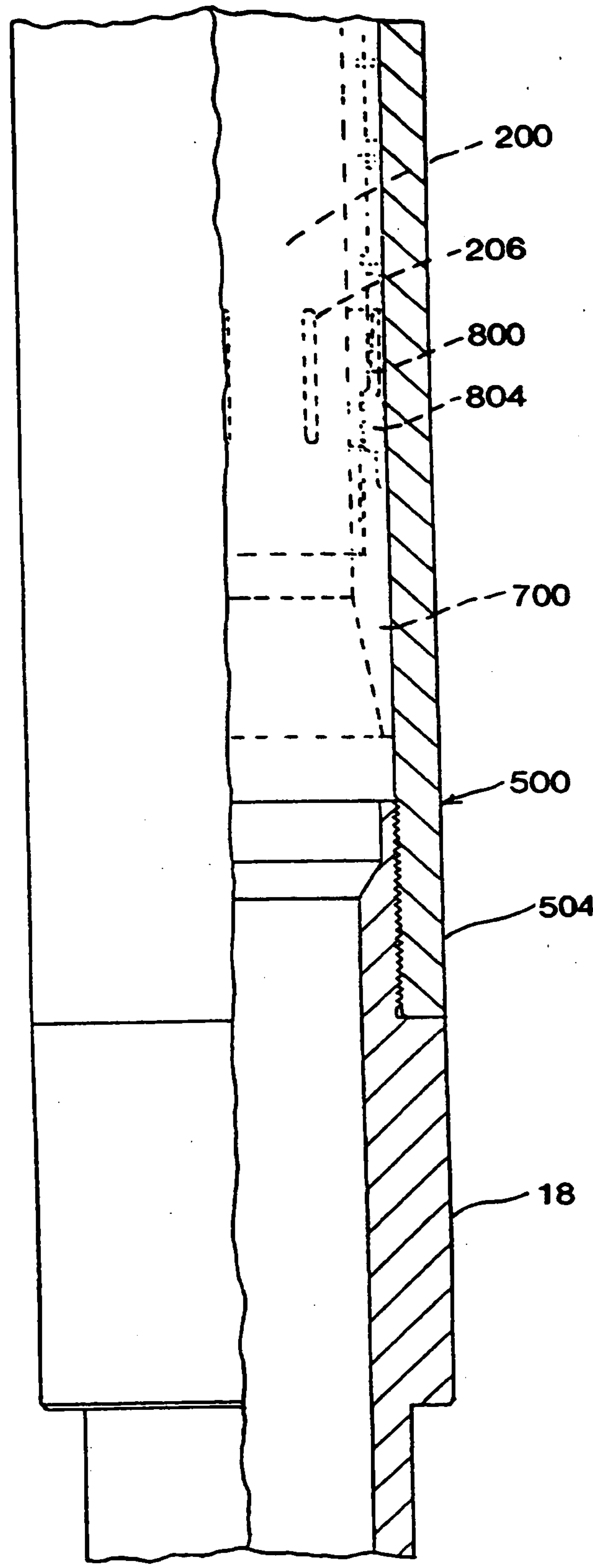

Fig. 2C

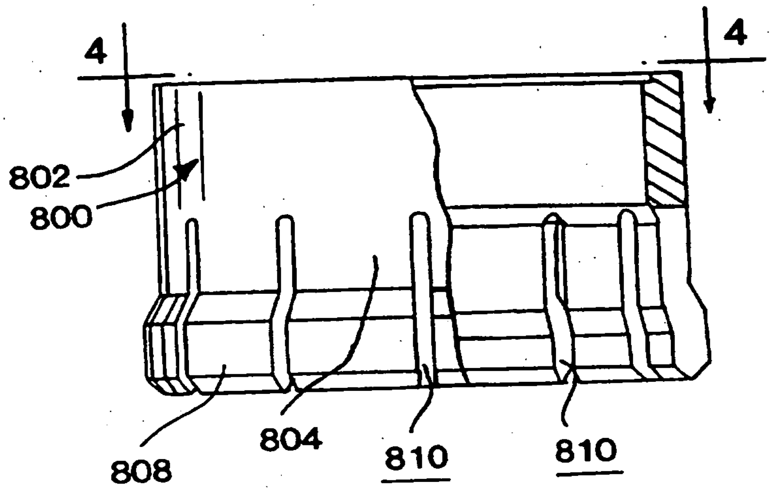

Fig. 3

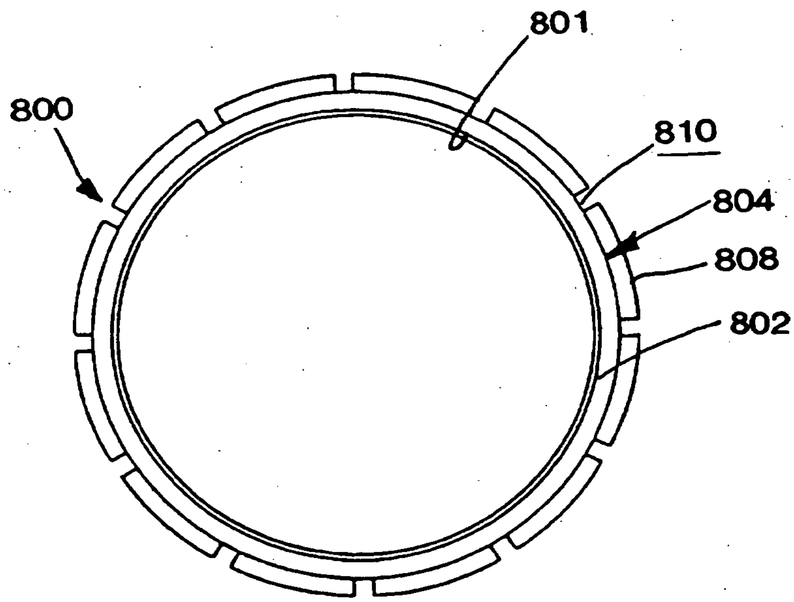

Fig. 4

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DISSOLVABLE RELEASE MECHANISM FOR TRAVEL JOINTS AND METHOD

This invention relates to method and apparatus for completing wells, and in particular to method and apparatus for locking a travel joint for placement in a subterranean formation and releasing the travel joint with corrosive means.

In the course of completing an oil and/or gas well, it is common practice to install a string of protective casing into the well bore and then to install a string of production tubing inside the casing. After installation, the casing is perforated across one or more production zones to allow production fluids to enter the casing bore. At the perforations, further stimulation methods are utilized to "horizontally" develop the production zone. These stimulation methods increase production yield of the formation, resulting in a general branching structure from the well bore at the perforation site.

A typical horizontal bore has a semi-circular curve having a radial dimension of about one-quarter of a mile that originates from the vertical well bore. Once drilled, casing or other well completion tubing is installed in the horizontal bore. Production and horizontal well bores are subject to formation settling, which occurs with the removal of liquids such as oil and gas from the formation. That is, the formation load shifts, affecting the well bore branch. If a branch is constructed without accounting for formation pressure load shifts, then the tubing tends to buckle due to excessive compressive and/or tensive loading. Inevitably a horizontal well bore will fail, requiring another rig set-up and associated rig time (trip time) and lost well production to replace the string.

Otherwise, that portion of the production is simply abandoned to avoid significant costs associated with drill time and well completion costs.

To compensate for formation load shifts during production, travel joints have been implemented in wells to compensate for the resultant tension and compression loads on the tubing string or the casing. The travel joints have inner components that telescope within the outer components of the joint.

Travel joints were typically run in the well with the inner components shear pinned to the outer components. Thus secured, the inner and outer components maintain their position relative to each other until the pins are sheared in the presence of a predetermined force communicated along the pipe string to the travel joint. The conventional methods for shearing these pins is either the application of the required tensive or compressive threshold loads to the travel joint, or through building adequate pressure down the tubing string. An example of a shear-type travel joint is provided in U.S. Patent No. 5,413,180, issued May 9, 1995, to Colby M. Ross et al. But a complication with shear-type travel joints is that the shear thresholds must be greater than commonplace compression and tensile forces that arise during placement of the travel joint. Otherwise, an erroneous shearing of the travel joint locking pins might occur, requiring that the "misfired" travel joint be retrieved and spending additional trip time expenses to complete the bore. Even if the shear-type travel joint is properly placed in the bore, then the required tensive or compressive threshold load applied to the travel joint is magnitudes greater than the initial compression and tensile forces encountered in the placement process. Typically,

specialized machinery is needed simply to generate and apply the threshold load. But as a result, other portions of the pipe string may be damaged by the excessive force.

Thus, a need exists for a travel joint which can be locked for placement in a horizontal bore, but that can also be selectively released to accommodate fluctuations in compressive and tensive forces in a well formation that could be caused by well production or natural formation fluctuations.

Provided is a dissolvable release mechanism to allow a travel joint to be run down-hole in a locked position to accommodate full compressive and tension loading integrity. The joint is released through exposure to caustic well fluids to accommodate well formation fluctuations in compressive and tensive forces.

In one aspect of the invention is a releasable well apparatus. The apparatus has a first and a second well equipment component movable relative to each other. A dissolvable release mechanism releasably secures the two well equipment component relative to each other. The release mechanism is selectively exposable to a corrosive well fluid for degenerating the release mechanism.

In another aspect of the invention, a method of releasing a travel joint having an inner travel joint tube received in an outer travel joint tube, the inner travel joint tube having a dissolvable snap ring reactive to a caustic well fluid. The snap ring is releasably maintained in an inner profile defined in the outer travel joint tube. The method comprises the steps of flowing a caustic well fluid

through an inner bore of the inner travel joint tube, and exposing the well fluid to the snap ring.

These and other features, advantages, and objects of the present invention will be apparent to those skilled in the art upon reading the following detailed description of preferred embodiments and referring to the drawings.

Reference is now made to the accompanying drawings, in which:

Fig. 1 is a schematic of a well bore and branch bore using an embodiment of a travel joint of the present invention;

Fig. 2A-2C is a longitudinal seal in view of an embodiment of a travel joint in accordance with the present invention;

Fig. 3 is an enlarged section view of dissolvable ring of an apparatus according to the present invention shown partly in section; and

Fig. 4 is an elevation view of the ring shown in Fig. 3.

Referring now to the drawings wherein like characters represent like or corresponding parts throughout the several views there shown in Fig. 1 bore hole 10 for a subterranean well. The well 10 is drilled more or less vertically through several layers of overburden and may turn from the vertical to a more or less horizontal orientation for purposes of placing as much bore hole within a productive stratum. Typically the well bore is supported against collapse by tubular casing 12 which is typically cemented in position in a manner well known in the industry. In addition, bore hole 10 may be formed with one or more branch bore holes 14 intersecting with casing 12. This embodiment is illustrated schematically in Fig. 1. According to the present invention, the branch bore 14 is likewise lined or cased to prevent collapse. According to the present invention, one or more travel joints 100 may be included in the branch bore hole liner along with conventional liner joints.

In addition, the release mechanism disclosed herein has applications in other well operations. The release mechanism has uses where a first and a second well equipment component are movable relative to each other. For well placement, the two components are locked together with a dissolvable release mechanism that degenerates with exposure to corrosive well fluids. For example, the dissolvable release mechanism can be used to secure components in a sliding sleeve valve such as that disclosed in U.S. Patent No. 5,012,871, issued

May 7, 1991, to Pleasants et al., the specification of which is incorporated by reference herein for all purposes.

Although only one travel joint 100 is shown in Fig. 1 positioned in the branch bore, it is anticipated that more than one travel joint 100 could be connected in the liner for the branch bore as needed.

As will be described, when a travel joint locking mechanism is released, the travel joint 100 can change in desired length to accommodate pressure and tension forces created over time by formation movement. In conventional wells without travel joints, these movements can deform and crumple the steel tubular component of the bore, causing the components to fail. The travel joint 100 accommodates these forces by allowing predetermined motion ranges through a telescoping action. For example, as is illustrated in phantom lines in Fig. 1, when the formation—in which the branch bore 14 is located—collapses and moves downward, the travel joint will shorten or lengthen, maintaining the integrity of the tubulars forming the branch bore.

As will be described in detail, the travel joint 100 is of the type which is initially rigid and of a fixed length to allow applying forces to the joint to install it in the well. Once installed the travel joint of the present invention can be unlocked by dissolving a locking snap ring as will be described in detail herein to allow relative telescoping movement and variations of the length of the travel joint to accommodate formation movement. The term "dissolvable" as used herein means corrosion brought on by chemical reaction to caustic well fluids sufficient to achieve structural degeneration.

Turning now to Figs. 2A - 2C the embodiment of the travel joint of the present invention is shown in the lock configuration with the release configuration in phantom lines in Fig. 2C.

Referring to Fig. 2A, string connector sub 16 is threadingly coupled to inner travel joint or inner mandrel 200. Inner mandrel 200 is slidably mounted in protector sleeve assembly 300, which has a protector sleeve 302 with a beveled first end 304. Beveled first end 304 is pinned to a seal carrier 306. Seal carrier 306 defines seal groove 308. Seal groove 308 receives O-ring 310. Defined between inner mandrel 200 and protector sleeve 302 is cylindrical void 312. Cylindrical void 312 is packed with a barrier material 314 that lubricates the engagement of protector sleeve 302 with inner mandrel 200, while also sealing the well bore 202. A suitable barrier material is petroleum grease.

Seal carrier 306 has a beveled outer edge 318 that generally aligns with protector sleeve first end 304. The resultant ramped surface facilitates movement of protector sleeve through the formation in response to load shifts.

Inner mandrel 200 has a limit shoulder 204. Limit shoulder 204, in conjunction with split ring 402 (Fig. 2B), defines the travel joint's longitudinal collapse limit when the joint is in the release configuration.

Referring to Fig. 2B, a second end 314 of protector sleeve 302 is connected to split ring retainer 400 with pins 316. Pins can be used to connect the protector sleeve to the split ring retainer 400 because the protector sleeve 302 is not a load bearing structure, but simply an insulation structure. Otherwise, a more rugged connection is used. Split ring retainer 400 has a generally cylindrical structure

separated by an enlarged ring portion 404. On one side of the ring portion 404 is a first flange portion 406 for receiving pins 316 and protector sleeve 302. On another side of the ring portion is a threaded second flange portion 412 for threadingly connecting the retainer 400 to a first end 502 of outer travel joint tube or outer seal housing 500. Second end 504 of outer seal housing is threadingly connected to pipe string 18 (Fig. 3C). It should be noted that the outer seal housing can be connected to other down hole devices and not simply terminate with the pipe string 18.

In Fig. 2B, shown is a tension lock assembly. The tension lock assembly has a split ring 402 secured between bottom surface 410 of split ring retainer 402 and mandrel tension lock shoulder 210 of raised mandrel ring 212. Tensile forces—illustrated in Fig. 2B as vector forces T_{500} and T_{200}—present on the travel joint 100 are conveyed through inner mandrel lock shoulder 210 by engaging the split ring 402. Tensile force T_{500} is the tensile force acting on outer seal housing 500 and Tensile force T_{200} is the corresponding tensile force acting on inner mandrel 200. The forces are communicated through ring 402 to split ring retainer 400. In turn, the tensile force is distributed to outer seal housing 500 and suspended pipe string 18 (Fig. 2C).

Still referring to Fig. 2B, shown is a releasable torsion lock assembly 600. Torsion lock assembly 600 is engaged with open slots 214 defined in raised mandrel ring 212. Open slots 214 extend partially through mandrel ring 212. Slots 214 receive torque lugs 506 threaded through outer seal housing 500. The torque lugs 506 and slots 214 communicate torque forces (generally applied

through use of drilling apparatus at the rig) from the inner mandrel 200 to outer seal housing 500. Preferably, the torsion lock assembly has at least three torque lugs 506 and open slots 214 in a circumferentially-spaced 120-degree relation with one another.

In Fig. 2B, shown is a compression lock assembly having a dissolvable release mechanism for releasable securing the well equipment components, such as inner travel joint tube 200 and outer travel joint tube 500.

As disclosed herein, the dissolvable release mechanism has a dissolvable snap ring 800 with a plurality of resilient fingers 804 locked or fixed in place by a tubular ring support 700. But it should be noted that the dissolvable release mechanism of the invention can be embodied by other releasable locking or securing configurations well known in the industry. Furthermore, the dissolvable release mechanism disclosed herein "prevents" relative movement, but other dissolvable release mechanisms can "limit" relative movement in a manner well known in the industry.

Inner travel joint tube or inner mandrel 200 has a ported end portion 220 having a plurality of longitudinal ports 206 extending therethrough. Well bore fluids seep through ports 206 into the snap-ring void 216. Snap-ring void 216 is defined between the recessed outer surface 208 of mandrel 200 and inner surface 508 of outer travel joint tube or outer seal housing 500. Fluid is limited to snap-ring void 216 by mandrel seals 218 and ring support 700. Seals 218 are slidably mounted to mandrel 200 with C-rings 219 and slidably engage inner surface 508.

Thus, even in the travel joint release configuration, the snap-ring void 216 volume is maintained within a desired region.

Ring support 700 is secured to the mandrel's ported end portion 220. With respect to the following discussion of the ring support, snap ring, and seal housing profile, references to orientations are made with respect to the orientations of these structures as illustrated in Figs. 2B, 3 and 4. Ring support 700 has a finger profile 702 extending from beveled edge 704. Finger profile 702 has a generally vertical surface portion 706 and a sloped portion 708 extending toward external circumferential surface 710. The outer diameter of ring support 700 is sufficiently less than an inner diameter of outer seal housing 500. Ring support 700 is placed within seal housing 500 to guide mandrel 200 within the seal housing 500 when the travel lock is released.

Inner surface 508 defines a corresponding finger profile 510 with respect to finger profile 702. Corresponding finger profile has a beveled surface 512, which is generally parallel and spaced apart from beveled edge 704. Extending from beveled surface 512 is vertical surface 514, which is generally parallel to surface portion 706. Vertical surface 514 extends to sloped portion 516 extending toward inner surface 508.

Contained in snap-ring void 216 is snap ring 800. Snap ring 800 has resilient fingers 804 that extend into the finger profile defined by ring support 700 and outer seal housing 500, creating a compression lock assembly. The ring support 700 profile provides a finger support surface, which is interposed between fingers 804 and mandrel 200 to effectively lock the fingers 804 into the finger

profile. As its name implies, the compression lock assembly prevents the travel joint from compressing, or collapsing, when compressive forces—commonly encountered by the travel joint during placement—are longitudinally exerted along pipe string 18 and outer seal housing 500. That is, as a longitudinal compressive force is urged against outer seal housing 500, the compressive force—illustrated in Fig. 2B as force vectors C_{200} and C_{500}—is not released or dispersed, permitting continued placement of the travel joint.

It should be noted that although snap ring 800 is shown secured about mandrel 200, other securing configurations can be had to achieve the same objective. For example, snap ring 800 can be secured about outer seal housing 500 and engage a profile in mandrel 200. Other various configurations can be had to secure seal housing 500 and mandrel 200 in a manner well known in the industry.

The compression lock assembly is released by dissolving the snap ring 800. The ring material is chemically reactive with the well fluids, causing the snap ring to weaken structurally over time. That is, the snap ring material has an accelerated corrosion rate relative to other well tool components in the presence of commonplace well fluids. Such materials preferably have a low tolerance of acidic, or low pH, well fluids. For example, the travel joint components are commonly formed of high-grade machine steel, which has a high-degree of structural stability and corrosion resistance. But also, the material used provides a degree of structural integrity to withstand compression forces C_{200} and C_{500} encountered

when the travel joint is being placed. For example, a suitable material is aluminum or aluminum composites. Preferably, the material is aluminum.

Acidic well fluids naturally occur from the formation or are introduced from the well site surface. Acidic fluids, such as hydrochloric acid, are introduced from the surface for formation maintenance or development purposes, such as stimulation processes or the like, which are well known in the art. But, the snap ring need only dissolve to the extent that it can no longer withstand structure load shifts. Thus, no specialized force is needed to unlock travel joint 100. Instead, the travel joint is released over time with commonplace exposure to caustic well fluids, which are seeped to snap ring 800 through mandrel ports 206. The snap ring degrades in the presence of the well fluids at a rate sufficient to accommodate shifts in the pipe line caused by the subsidence of the surrounding subterranean formation. It should be noted that caustic well fluids can be introduced into the well bore 202 for dissolving or corroding the snap ring without waiting for incidental exposure to commonplace well fluids used to complete the well.

Referring to Fig. 2C, shown in phantom lines is the inner mandrel 200 placed into a fully collapsed position within travel lock 100. The fully collapsed position is designated by the placement of the extension limits provided by split ring 402 and limit shoulder 204. As illustrated, snap ring 800 has sufficiently dissolved to the extent that it does not remain within the finger profile—defined in outer seal housing 500 and ring support 700—when tensive or compressive forces act on travel joint 100. It should be noted that once travel lock 100 is released, travel joint 100 can accommodate both tensile and compressive forces by "stroking"

within travel joint's extension limits and compression limits (designated by mandrel shoulder 210 and split ring 402).

Referring to Figs. 3 and 4, snap ring 800 has a cylindrical base portion 802 with a plurality of integral downward-extending fingers 804. Fingers 804 form a substantially cylindrical portion with an inner diameter greater than an inner diameter of base portion 802. Fingers 804 have tapered tips 808, which are offset outwardly with respect to base portion 802. The offset of tapered tips 808 is best shown in Fig. 4. Fingers 804 define slots 810 therebetween such that fingers 804 each can independently deflect or "snap" into the finger profile defined by ring support 700 and outer seal housing 500, discussed above. The spacing apart of the snap ring fingers 804 also increases the ring surface area exposed to caustic well fluids. As discussed above, these fluids seep through mandrel ports 206 into void 216(Fig. 2B), which contains snap ring 800.

It will be appreciated that the invention may be modified within the scope of the appended claims.

CLAIMS:

1. A releasable well apparatus comprising: a first and a second well equipment component movable relative to each other; and a dissolvable release mechanism releasably securing said first and said second well equipment component, said release mechanism selectively exposable to a corrosive well fluid for degenerating said release mechanism.

2. A releasable well apparatus according to Claim 1, wherein said dissolvable release mechanism releasably secures said first and said second well components by limiting relative movement of said first well component with respect to said second well component.

3. A releasable well apparatus according to Claim 1, wherein said dissolvable release mechanism releasably secures said first and said second well components by preventing relative movement of said first well component with respect to said second well component.

4. A releasable well apparatus comprising: an outer travel joint tube having a finger profile defined in an inner surface; an inner travel joint tube receivable in said outer travel joint tube, said inner tube having a ported end portion defining a plurality of ports extending therethrough; and a dissolvable release mechanism about said ported end portion adjacent said plurality of ports, said release mechanism locking said inner travel joint tube with respect to said outer travel joint tube.

5. A releasable well apparatus according to Claim 4, wherein said plurality of ports are circumferentially-spaced longitudinally extending slots.

6. A releasable well apparatus according to Claim 4 or 5, wherein said release mechanism is made of a material for chemically reacting with a corrosive well fluid communicated through said plurality of ports.

7. A releasable well apparatus according to Claim 6, wherein said material is an aluminum composite.

8. A releasable well apparatus according to Claim 6, wherein said material is aluminum.

9. A releasable well apparatus according to Claim 6, 7 or 8, wherein said corrosive well fluid has an acidic pH value.

10. A releasable well apparatus according to any one of Claims 4 to 9, wherein said dissolvable release mechanism comprises: a dissolvable snap ring having a base portion with a plurality of resilient spaced-apart fingers extending therefrom, said fingers having tips that are generally offset outward with respect to said base portion for generally engaging an inner surface of said outer travel joint tube, said fingers receivable in a finger profile portion defined in an inner surface of said outer travel joint tube; and a tubular ring support receivable within said outer travel joint tube, said ring support securable to said ported end portion and a finger support surface interposed between said plurality of fingers and said mandrel tube for locking said plurality of resilient fingers within said finger profile portion of said outer travel joint tube.

11. A releasable well apparatus according to Claim 10, wherein said mandrel has a recess portion defined on an outer circumference of said inner travel joint tube across said plurality of ports, said recess portion adjacent to said plurality of fingers.

12. A releasable well apparatus according to Claim 10 or 11, further comprising: a plurality of inner travel joint tube seals slidably mounted to an exterior of said inner travel joint tube adjacent said base portion of said dissolvable snap ring.

13. A travel joint assembly comprising: an outer travel joint tube having a substantially cylindrical inner surface; an inner travel joint tube receivable in said outer travel joint tube, said inner tube having a ported end portion defining a plurality of ports extending therethrough; a tension lock assembly for communicating a tensive force between said outer travel joint tube and said inner travel joint tube; a torsion lock assembly for communicating a torque force between said outer travel joint tube and said inner travel joint tube; and a compression lock assembly having a dissolvable release mechanism for releasable securing said inner travel joint tube relative to said outer travel joint tube, said release mechanism reactive to a corrosive well fluid

communicated through said plurality of ports to said release mechanism.

14. A travel joint according to Claim 13, wherein said dissolvable release mechanism comprises: a dissolvable snap ring secured about said ported end portion adjacent said plurality of ports, said dissolvable snap ring having a base portion with a plurality of resilient spaced-apart fingers extending therefrom, said fingers having tips that are generally offset outward with respect to said base portion for generally engaging said inner surface of said outer travel joint tube, said fingers receivable in a finger profile portion defined in said inner surface of said outer travel joint tube and fixed in said finger profile portion by a ring support secured to said ported end portion.

15. A travel joint according to Claim 13 or 14 wherein said dissolvable release mechanism is made of a material for reacting with the corrosive well fluid communicated through said plurality of ports.

16. A travel joint according to Claim 15, wherein said material is an aluminum composite.

17. A travel joint according to Claim 15, wherein said material is aluminum.

18. A travel joint according to any one of Claims 13 to 17, wherein said corrosive well fluid has an acidic pH value.

19. A method of releasing a travel joint having an inner travel joint tube received in an outer travel joint tube, the inner travel joint tube having a dissolvable release mechanism reactive to a corrosive well fluid, the release mechanism is releasably maintained in an inner profile defined in the outer travel joint tube, the method comprising the steps of: flowing the corrosive well fluid through an inner bore of the inner travel joint tube; and exposing the release mechanism to the corrosive well fluid.

20. A releasable well apparatus substantially as herein described with reference to and as shown in the accompanying drawings.

21. A travel joint assembly substantially as herein described with reference to and as shown in the accompanying drawings.

22. A method of releasing a travel joint substantially as herein described with reference to and as shown in the accompanying drawings.

The Patent Office

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Application No: GB 9800389.0
Claims searched: 1-22

Examiner: Robert Fender
Date of search: 20 March 1998

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.P): E1F: FJB

Int Cl (Ed.6): E21B

Other: Online WPI

Documents considered to be relevant:

Category	Identity of document and relevant passage	Relevant to claims
X	GB 2296023 A (HEAD)	1

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.